A survey of networked and Wi-Fi enabled practices to support disabled learners in museums

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***Abstract*— This article reports on a survey of network and Wi-Fi enabled technologies to support disabled learners in museums and similar cultural heritage environments. In this study, literature is classified using the Epistemological Model of Disability, classifying and defining methodologies and ontologies as it does so. Data was collected using a systematic literature review using six academic databases, which included peer-reviewed articles from a range of sources. The analysis addressed two research questions, and was developed in three phases: the first phase examined trends, definitions and methods of teaching and learning in cultural heritage; the second categorized genres that emerged in the first phase and discussed meta-levels; the third developed a critical discussion on teaching and learning models. The study had two principal findings: 1) museums have done much to make themselves part of the inclusion agenda, 2) more needs to be done to improve management strategies, increase agency and reduce practice using deficit models.**

Keywords—disability, impairment, learning, Wi-Fi, tablet, cell phone, m-learning, museum, cultural heritage.

I. INTRODUCTION

This article reviews learning models for Disabled Learners (DL) in museum environments or through museum websites using technologies with network and Wi-Fi capabilities. The epistemological analysis—that is, the analysis of knowledge created through academic documents—in this article focuses on improving learning with mobile technologies, access to education for DL, and the advantages or potential issues of learning with mobile technologies for DL. This form of analysis is based on a previously developed Epistemological Model of Disability, which was used during the study as a means of evaluating existing studies and literature, building on their findings and engaging critically with their methodologies and ontological assumptions in order to develop more effective models of design and research [1].

The research is conducted through a systematic literature review, using English as a medium of search. The review was conducted to inform the early phases of the ARCHES research project, a project designed to use and test new and existing inclusive technologies in museum environments [1]. In particular, the study identified pathways for future designs and more importantly informed the learning strategies and exercises used during ARCHES. For example, teaching methodologies identified in the literature on largely wireless technologies helped to contextualize participants' practice when using Wi-Fi functions on tablets and their cell phones. Subsequently, this process helped participants provide feedback about their learning experiences during workshops and feedback sessions [2]. The ARCHES project was also commissioned to develop mobile and augmented technologies, to make cultural heritage environments more accessible, and to develop a broader ranging evaluation of inclusive technologies. Thus, this and other literature searches were developed to inform the design and implementation of Wi-Fi enabled products, particularly its apps and systems software.

The survey and this early stage of the ARCHES project had three aims: 1) to inform practice in museums, and the testing and development of future technologies; 2) to evaluate modes of learning by DL using technologies as a tool of inclusion; 3) to develop resources that could inform researchers and practitioners about contemporary developments in the teaching of DL in cultural heritage environments. To achieve these aims, the following article is set out in four sections: the first section discusses the methodology used to construct the search, and conduct the analysis; the second section presents the first two phases of analysis of the literature; the fourth section is a discussion of the findings and forms the third phase of analysis; the fifth section concludes the study.

II. Research Methodology

As previously mentioned, the study was conducted using a systematic literature review methodology. This method was split into two parts: the method of search and the method of analysis. The method of search itself was conducted in two phases, and the analysis was developed in three phases.

A. The Method of Search

The search used databases of academic, peer-reviewed literature, and was restricted to the following parameters: date range: Literature from the last ten years was favored, although older materials that were found to be highly relevant were accepted if they were felt to inform the overall study; Language: English; Literature databases: EBSCO, British Education Index, IEEE Xplore, ACM, SCOPUS, and Google Scholar – these databases were chosen, as they covered educational and technological literature, and also included universal academic databases that comprised generalist, disability studies and museum studies titles; Types of publication: Journal articles were preferred, but relevant monographs, book chapters and conference papers were also considered; Inclusion criteria: Articles were to be original research or based on discussions of innovative practice or theory which feature practices which could include wireless and networked technologies.

Three levels of search term were included and used Boolean <AND> searches from three categories of keyword. The search terms and levels were as follows: First level: Disability, Special Need(s), Impairment(s); Second level: Learning, Education, Museum(s) – the phrase Cultural Heritage was felt to be too restrictive as it could pick up extraneous work broadly related to culture; Third level search: Technology, Mobile Technology, Computers. The mixing of keywords ensured that literature which included all three topics of research focus were identified. Consequently, in each literature database, n=36 separate searches were conducted using this three-level search strategy.

Commercial or brand names were deliberately excluded from the search, as it was intended to focus on practice and not technology. During the search, it was also decided to use broad search terms to describe disability, even though the study specialized in DL, as it was felt that research covering individual sensory, physical or learning impairments could be favored by authors. Furthermore, it was recognized that, although some people had multiple impairments, people often identified themselves by a single impairment, such as *being* deaf or blind.

This search produced a large selection of documents, most of which were found to be irrelevant, as they related to other cultural settings or disabilities outside the scope of the survey. A large number of conference papers were also rejected because they were only available as abstracts or could not be obtained; similarly, many books were rejected because they were out of print or were "pay for publishing / self-published" books, or their peer reviewed status was unclear. After these inappropriate documents were rejected, the survey initially produced n=111 reports, conference papers, books, chapters from edited collections and journal articles. A further level of rejection was then made, as it was found that although they included cultural heritage many articles did not focus on learning in museums or other cultural heritage environments; other documents were also rejected because they did not include appropriate technologies. This level managed to reject many of the articles for their inappropriateness, and left n=39 articles for consideration by peer-review.

The documents that were downloaded where available and their references and abstracts were recorded in an Excel spreadsheet, which were then peer-reviewed by another member of the ARCHES team. After filtering the articles, the Excel spreadsheet was divided by those that successfully passed peer-review. The peer reviewer judged whether the paper should be included in the review based on the extent to which it addressed the following two research questions. These research questions were based on the criteria of the overarching theme of the review; and, as with the original search of the databases with the inclusion criteria, each article had to address at least one of the questions: *1) What forms of learning underpin learning in cultural heritage? 2) How does the use of technology which are networked serve learning in museum environments?* As the final criteria were strict, this two-level filtering process reduced the number of papers to n=18 articles, which were analysed using the three-phase process.

B. Analysing the literature

The analysis of literature was conducted in three coding phases, using a model that was similar to other parallel systematic literature reviews for ARCHES [3][4]. These three phases encouraged the evolution of culturally deduced trends in the literature, broadly following an increasingly focused approach:

- During the first phase of analysis, definitions and methods of research were compared with each pass identifying initial critical issues, such as the disparity between different academic disciplines. During this phase of analysis, categories such as teaching methods, strategies of learning, use of technologies and learning environments were also identified. From these categories, patterns linking the articles at a deeper level were examined.
- During the second phase of analysis, links between individual categories were made. This strategy provided a focus for identifying "genres" of literature according to their characteristics, such as which discipline they referred to, how they described the use of technology and the practices they saw as fundamental. In addition, during this phase links between study topics and user groups were defined and reviewed to determine latent correlations that formed sub-concepts [5]. The initial nature of these patterns and correlations were then established.

  Subsequently, a meta-analysis of the chosen categories was developed into topics for discussion. Also during this phase, literature that did not appear to be initially relevant, or that did not provide latent patterns or concepts were filtered out. From this categorization, more refined concepts and latent patterns were thus formed, relating to all categories of article.
- During the third phase of analysis, the literature was re-examined using explication de text (i.e. a careful reading of texts examining key terms), in light of analysis through genres and identification of concepts and patterns in the articles [6]. This analysis directly addressed the questions

used to review the literature. In addition, during the third phase of analysis potentially false assumptions that were not supported were rejected.

III. Results

A. First Phase: Overview of the Literature

Although the sample could not show a robust, empirical theory of museum teaching and learning using networked technologies, common variables emerged in the articles. These variables included: negative attitudes about the intellectual capacity of DL; the age range of DL; the intended purpose of technology use; the use of technology that drove the teaching and learning strategies; and whether the article was an evaluation, review or theoretical article. Despite these generally common themes, the studies did not use a common definition of disability or special need. Furthermore, as these articles came from a range of countries the individual legislative frameworks governing inclusion, disability and special needs differed markedly. This meant that the concept of social inclusion and inclusive learning using networked technologies changed frequently.

For instance, N=9 articles described disability or special needs as a single category – i.e. all DL needed to be supported with common strategies no matter what the impairment. Of the remaining articles, the most frequently mentioned impairment was visual impairment, with n= 7 articles. Furthermore, two of the "all disability" articles emphasised sensory impairment over all others – with an emphasis on learning through touch. The remaining n=2 articles referred specifically to the museum based education of people with learning disabilities alone. The articles mentioning DL with specific impairments, discussed learning strategies based on enhancing what was felt to be a deficit in their behavior, cognitive ability or perception. More than half the articles also focused specifically on age groups, with n=9 articles discussing school children exclusively and n=2 articles featuring adults, with the remaining n=7 articles featuring teaching of all or no specific age groups. The majority of articles, n=11 articles, were evaluations of teaching strategies, whereas n=2 articles were theoretical discussions of the potential of technologies / teaching strategies, with the remaining n=5 articles being surveys of people's experiences of teaching and learning both with non-DL and DL, and as groups of only DL with non-DL supporters.

Half the articles, n=9 articles, discussed specialized teaching techniques using technologies as a focus of teaching and as a tool of support for use by DL, such as differentiated learning [7]. Of the studies using technologies at the core of learning or support, n=5 articles promoted multi-media strategies, with the remaining n=4 studies promoting multi-sensory or cross-modal strategies – i.e. technologies that stimulated all the senses in order to form a homogenous sensory "image" [8]. All but one article, n=17 articles, discussed adaptive teaching and learning strategies for DL, based on physical or intellectual adaptations. Only one article discussed the use of technology as a tool to educate *about* disability.

These observations on variables identified by the search led to a more focused examination of literature that worked towards category formation. It also led to the rejection of outlying trends. For instance, only n=1 article featured learning by school children alone, only n=1 article featured adult DL alone or discussed learning through social media or the Web. The other forms of learning were what could be termed passive forms of learning, that is a trail or exhibition which was designed to be followed in a particular way. Alternatively, only n=1 article concentrated on discussing the physical access of DL; and only n=1 article featured a form of participatory design to inform teaching and learning strategies, where DL were invited to develop their own forms of learning using technologies.

Of the n=7 articles featuring DL with visual impairments, n=4 articles discussed touch as the primary form of learning, with the remaining n=3 articles focusing on verbal imaging or audio description – although there were elements of verbal imaging in the touch focused articles and touch in the verbal imaging focused articles. Of the n=9 articles featuring school children, the learning discussed was either largely or solely related to school visits or school-aged courses organized by museums. Conversely, n=7 articles discussing learning by all age groups discussed independent visits to museums to interact with exhibitions. Only the remaining n=1 article on all age groups and the n=1 article on adult teaching and learning featured verbal imaging / audio descriptions in organized visits primarily for verbal imaging of artworks.

From this first phase of analysis, there appeared to be no single or coherent strategy of learning for DL in museum environments using networked and Wi-Fi enabled technologies. This lack of a single strategy could potentially slow access for disabled people, as different countries have different strategies and are at different stages of inclusion in museums. However, themes emerged across a number of articles, and these could be expressed as categories of teacher-approach. Furthermore, although not well defined, there was either an understanding of disability as a deficit of cognition, behavior or perception that needed support, or as a victim of social exclusion that needed rectifying. These initial observations were taken forward to the creation of three categories of analysis, each showing two distinct contrasting approaches to learning. These categories are discussed in the second phase of analysis.

B. Second Phase: Analysis of Three Categories (Epistemological Paradigms) of Teaching and Learning

The three epistemological ways of categorizing the studied forms of teaching and learning according to the EMD were as follows: 1) learning focusing on direct guidance or teaching versus learning independently - with guided learning of school children for educational purposes being seen as different from independent, non-age-specific learning or adult learning; 2) learning focusing on fixed technologies versus learning through mobile technologies - with learning through fixed technologies being largely related to specific environments and mobile technologies not bounded by a specific museum or gallery space; 3) learning focusing on perceptions versus learning through language or discourse - with the learning primarily through the senses being largely passive, and learning through language being distinctly interactive. These are discussed below as three units of epistemology, which are referred to as Epistemological Paradigms (EPs) for the purpose of this study:

EP1: Learning focusing on direct guidance/teaching versus learning independently: Guided teaching and learning comprised the largest form of teaching and learning in the museum in EP1, with n=11 articles discussing this methodology. All but n=1 article [9] of the guided learning literature featured age-specific groups, and by default all of the school based teaching and learning strategies involved guided exercises or projects. This need to base guided exercises on age specific museum visitors was thought to be largely due to the different learning styles of different age groups, and the different focus of attention of adults. It was also observed that adults, particularly older adults, had very different learning needs, and their learning was largely for cultural enjoyment, well-being and belonging. For example, technology assisted verbal imaging and touch tours of galleries by blind and visually impaired adults were felt to benefit the interests of visitors [10]. Similarly, adult learners whose touch and verbal imaging tours featuring technologies and group discussions not only benefited visitors intellectually but helped in forming close social bonds [11]. School children's guided teaching and learning was focused on three particular teaching and learning strategies, which were felt to enhance the children's future learning needs: social and didactic development through exhibits [12][13][14][15]; the perceived need to develop sensory perception through interaction with exhibits [16]; and the need to understand exhibitions with "real" objects through sensory development [17][18][19][20] - although it should also be noted that many of the articles had elements of perceptual development, socialization and didactic learning. Only n=2 articles in the search had an explicit link between museum visits and the school curriculum, each study finding there was little joined up thinking between schools and museums [14][20]. The remaining literature, which focused on two independent learning strategies in the museum, were thought to develop or enhance experiences: the development of routes and exhibitions designed to evoke the understanding of exhibits and maquettes, with accessible text – either Braille, written or verbal information – designed to develop intellectual knowledge and well-being [21][22][23][24][25]; and the design of the contents of exhibitions to promote social justice for people with disabilities [23][26].

EP2: Learning focusing on fixed technologies versus learning through mobile technologies: Only n=3 articles focused on technologies that could be said to be either wholly fixed or mobile in EP2, the remaining n=15 articles in theis EP discussed a mixture of fixed or mobile technologies, with the latter relying mainly on Wi-Fi. However, in this search it was observed that even the mixed studies concentrated on learning strategies with mobile technologies or fixed technologies in support of exhibitions [12]. Consequently, teaching strategies were categorized as if the technology was the main focus of learning, where both forms of technology were discussed equally [18]. Articles focusing on fixed technologies appeared to concentrate on three teaching and learning strategies: 1) the design of bespoke exhibitions for DL, in which the technology was an integral feature of the exhibition [21][23][26]; 2) the design of inclusive exhibitions with technologies designed to provide experiences for all users, including DL [15][25]; and 3) the integration of technologies in existing exhibitions to make them more accessible to DL [13][14][16][19][20][22][24]. Conversely, articles featuring mobile technologies focused on their use in three different ways: 1) as technologies in and of themselves to stimulate social interaction and socio-development [12][14]; 2) as technologies used in combination with fixed technologies, to simulate or augment fixed technologies, allowing interaction with an exhibit [17][18]; and 3) as a tool to verbally image or audio describe exhibits in the presence of the objects [9][10][11].

EP3: Learning focusing on perceptions versus learning through language: As with the use of fixed and mobile technologies, there was only n=1 article that focused on the use of language alone as a tool of teaching and learning in EP3 [9]. The remaining n=17 articles in this EP had an element of perceptual learning or language learning, although again there was a significant focus on one as a leading mediator of teaching and learning. For instance, one of the articles discussed an exhibition featuring the use of video that was primarily focused on the use of language, despite their reliance on multi-sensory formats, including poetics and video art [26]. The development of learning and teaching mediated primarily through language was focused on four teaching and learning strategies: 1) the DL being a passive recipient of language through exhibitions, where the social message produced by the designers was preeminent [26]; 2) the development of higher language and social skills [12][13]; 3) teaching the contents of objects that are thought to be unperceivable through other means, such as painting to viewers with visual impairments, or articles where touch was prohibited [10][11]; and 4) the interaction with virtual museums that can't be visited in person [14]. Furthermore, it was observed that articles focussed on direct sensory experience to develop discussions on teaching and learning through three different strategies: 1) the development of understanding through the stimulation of senses, where one sense was impaired [17][18][20][21][22]; 2) where learning was felt to be improved by interactive activities or what was being taught was designed to be experienced interactively [15][19][25]; and 3) where it was felt that learning through language was impaired, the sensory experience of exhibits was designed to provide at least a partial substitution [23][24].

Although the categories discussed in the second phase were not wholly discrete – i.e. there was an overlap in the categories of teaching and learning – there were distinct foci in the discussion of their learning strategies. In particular, within each category of learning strategy there were learning trends. For example, the learning strategies designed for age specific audiences were comprised of discrete theories of technology usage or usage of networks. In addition, there were also distinct trends in the literature that ran across all categories. Most particularly, the guided teaching and learning exercises were more likely to feature mobile technologies, and focus on social and language based teaching and learning strategies. Conversely, fixed technologies were also more likely to be linked with independent learning strategies. Given these trends within and between categories, teaching and learning strategies focusing on language and socialization are usually supported through mobile technologies and are age specific. Thus, fixed technologies are more likely to be associated with independent DL, whose age is less specific and less easily defined.

The refined categories developed in the second phase of analysis were taken forward into a critical discussion of the

literature, according to contemporary philosophies of educational technology. This discussion was conducted in accordance with the questions that were at the heart of the literature search, and featured in the methodology section.

IV. Discussion

A. Analysis of the Epistemological Paradigms

Traditionally, DL have often been excluded from museums because of their elitist nature and a belief in the deficit of LD [27][28]. However, as the analysis in this systematic literature search showed, more recently DL have been incorporated into contemporary museums' inclusion agendas. Consequently, this community of museum visitors now often benefit from the development of bespoke exhibitions and technologies, and benefit from the opportunity of using technologies in a number of different exhibitions. There is also a willingness to develop inclusion over a long period of time, with school children particularly encouraged to attend the museum to develop a sustainable community for years to come (see for example, [29]).

The categories discussed in this review, which feature learning strategies for DL using networked and Wi-Fi technologies, appear to conform to this broader inclusion agenda, and inclusion is mostly achieved through three distinct methodologies:

- The first methodology is the development of fixed technologies and exhibition content that allows for independent exploration and interaction within exhibitions [14][21][25][26]
- The second methodology is to make museum exhibits themselves more interactive, either through mobile technologies [9][10][11][14][17][18][21] or seeing exhibitions including innovative technologies as inclusive technologies [13][15][19][20][21][22][23][25][26].
- The third methodology is to develop social interaction, either through interactive description or through social networking using mobile social networks [9][10][11][12][13][21]; although many of these strategies were based on verbal imaging of exhibitions, and so socialization was not their primary aim.

However, despite their emphasis on inclusion, several articles identified at least one of three issues that hampered the full inclusion of DL, using these teaching and learning methodologies:

- Firstly, articles focusing on DL with specific impairments observed teaching and learning methodologies often comply with a deficit model of disability [30] – i.e. teaching and learning that is designed in the belief that DL are incapable of "normal" interaction with museum exhibits. For example, many inclusive strategies for people with visual impairments in museums are often based on the belief that people with visual impairments lack any vision [10][21].
- Secondly, many of the articles reviewed observed that either the miss-management or lack of management of teaching, learning and curricula led to the exclusion of DL in museum environments [22][24][20].
- Thirdly, few articles featured in this search provided a sense of agency for DL – i.e. the empowerment of people with disabilities either through participation in the design of teaching and learning, or the design of artworks or objects that were being taught [9][26][23][10].

B. Analysis of the Epistemological Model of Disability

With reference to the EMD, the instrument of analysis in this article, the *use* of methodology seemed to show an ontological different to approaches in all three EPs. For example, the literature in EP1 often explored existing mobile settings and apps to support DL, whereas the other EPs used customized systems. The literature in EP1 also rarely assumed DL's levels of disability and focused on the needs of individual learners or classes instead. Another difference between literature in EP1 was that it often focussed on mobile technologies as tools of personal development rather than support. Therefore, literature in EP1 was less likely to support more traditional models of assistive technology through the use of a deficit model [5].

Importantly, it was observed that the construction of EPs on Wi-Fi enabled learning environments for DL now needs further refinement. For instance, and as observed above, there is a loose trend in all three EPs that suggests that the epistemology of assistive technology for LD is slowly moving towards an appreciation of inclusive technologies, such as those used in ARCHES [1]. Similarly, although EPs emphasized separate technologies, the literature was more likely to place an emphasis on the design of custom software in mainstream technologies. This also seems to reflect an epistemological trend for the social and cultural acceptance of disability. In addition, it also demonstrates that LD are more likely to receive positive social reinforcement from the use of adaptive technologies, such as tablets and smart mobile devices, rather than traditional devices. Consequently, it can also be argued that there is social will to support an inclusive technology model [1],[5], although at present, methodologies are still too young to be able to form a single EP of research in this field to take this forward.

Subsequently, ARCHES research partners observed overall that not only are EPs currently limited in scope, there is also little coherent theory or social or cultural development to suggest that a developed form of access currently exists in museums. More importantly, despite the rhetoric of much of the literature, there is limited coherence in EPs across and between museums. Thus, although strategies of teaching and learning can be formed into EPs that have broad relationships, the topic of networked and Wi-Fi enabled technologies for DL in museums as a whole lacks ontological and epistemological maturity and public debate.

V. Conclusion

This survey showed ARCHES researchers that there appeared to be three issues that needed to be considered when developing technologies for inclusive practice in museums. The first element was disabled participants in the research needed to be able to consider the development of teaching and learning

strategies in a collegiate manner, in order to provide agency for DL as a whole. Only in this way, will networked and Wi-Fi enabled technologies have use within the context of learning within the museum.

The second element was that DL learn more effectively if a diverse range of sensory stimulation is provided – i.e. without assuming that senses are discrete – and by developing a discourse about these sensory experiences through social networking and interaction. In this way, DL not only develop a greater sense of knowledge from these technologies, but also feel a greater sense of well-being from the social interactions that museum visits engender.

The third element was that networked and Wi-Fi enabled technologies cannot be seen as discrete technologies devoid of a single museum context. As the literature shows, ineffectual management can reduce the inclusive benefits of inclusive technologies, no matter how well they are designed or the purpose of their use. More particularly, if staff are not trained to work with DL, and management do not coordinate across museums to develop a coherent approach access agendas, then technologies will not become an effective tool of teaching and learning

Therefore, it is recommended that communities of practice of museums and technology companies that include people with disabilities at the heart of their decisions should be encouraged. Museum professionals and policy makers also need to understand that inclusion is not simply a technological or teaching issue, but an issue of attitudes and a state of mind.

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